Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. VII, 2018
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

ASPECTS OF DIGIZATION IN AGRICULTURAL LOGISTICS IN GERMANY

Heinz BERNHARDT, Michael MEDERLE, Maximilian TREIBER, Sascha WÖRZ

Technical University of Munich, Agricultural Systems Engineering, 2 Am Staudengarten, Freising, Germany

Corresponding author email: heinz.bernhardt@wzw.tum.de

Abstract

Digitization is one way to fulfil the demands on agricultural logistics. The growth in farm size and new branches mean that logistics is becoming ever more complex. A simple takeover of systems from the general logistics is not possible because of the special conditions of agriculture. First offers for digital logistics in agriculture are on the market. These are usually only for small areas and not complete chains. Often there are still difficulties with data availability and interfaces. There are first solutions for digitization in logistics across several levels of trade. These work if the partners are well organized and agree. If this confidence does not exist, digital collaboration is also difficult. A big problem that still has to be solved is data ownership and privacy.

Key words: *Logistic, Digitalization, Data Management, Data Privacy Protection.*

INTRODUCTION

Logistics plays a crucial role in agriculture. Between field, stable and trade many different goods have to be transported. In recent years, the importance of logistics in agriculture in Germany has increased. The quantities and distances per farm have increased. This has different causes: the growth of the farms, the reduction of the locations of trade and the biogas boom (Bernhardt, 2002; Götz, 2015).

At the same time, the demands on logistics have increased. As the consumer in Germany is very critical about food safety all goods flows from the field or stable to trade must be traceable. Logistics is no longer just about the transport and handling of the goods but also on the data belonging to the transported goods (Seufert, 2006; Folinas, 2015). The aim of the farms is also to optimize the processes in agricultural logistics. Especially in large logistics chains e.g. the transport of 500 ha of silage maize for a biogas plant cost reduction plays a decisive role. The resource manpower must also be used optimally as it is important for logistics processes and there are always less well-trained drivers available (Heizinger, 2011; Sonnen, 2007).

All of this means that digitization in agricultural logistics is increasingly being used to solve the problems that arise. The effects can be subdivided into several areas. These are:

- the comparison with industrial logistics;
- the hardware and software used;
- the impact on marketing.

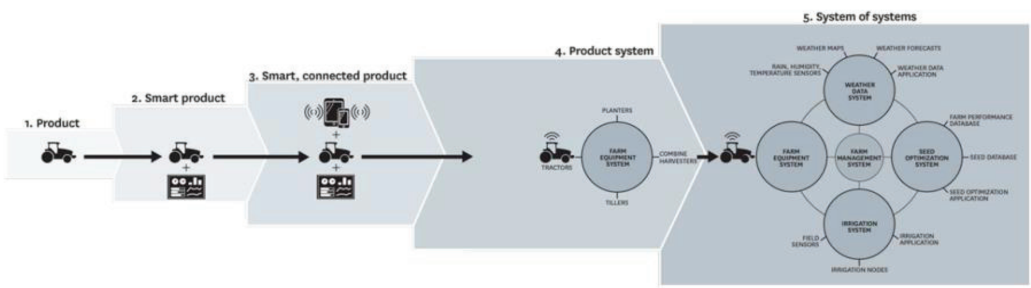


Figure 1. Data management in agriculture (Proter and Heppelmann, 2014)

Comparison of general logistics and agricultural logistics

Digitization is currently playing a crucial role in all sectors of the economy. In Germany, all these efforts are summarized under the term "Industry 4.0" which describes the complete digital networking of all production processes. It could be assumed that agriculture can directly take over the developments in the field of general logistics but it shows that agricultural logistics has considerable structural differences compared to general logistics. A key difference in agricultural logistics is that here the sources and sinks in logistics move during the process. In general logistics the starting point and target are always specified and therefore long term planning is possible. In agriculture the start point and target can move in space during the logistics process. The combine harvester, for example, moves on the field during harvesting. The precise location on the field on which it has to overload the grain onto the transport vehicle is difficult to determine previously because factors such as yield, driving patterns on the field, soil properties, the driver's operation etc. are difficult to simulate. This considerably complicates the preliminary planning as both vehicles continue to move during the reloading (Sonnen, 2006; Heizinger, 2014; Rusch, 2012; Wörz, 2017; Lamsal, 2016).

The agricultural logistics are also different in that the transport is generally carried out with tractors. Transport from the field to the road happens with the same technology. The transport vehicles must therefore be able to drive both in the field and on the public road. Therefore, it is difficult to use technology from the general logistics, optimized for the road, in agriculture. This structure of agricultural transport technology in Germany has grown historically and can only be changed with a complete change of organization and technology (Götz, 2014; Götz, 2011).

Hardware in agricultural logistics

Agricultural logistics has been marked by digitization in recent years. A good example of this is the use of navigation systems in agriculture (Kluge, 2015). For large logistics chains, such as the harvest of silo maize it is important for the transport vehicles that they are on time with the forage harvester. For this purpose, navigation systems have been used for several years. These differ from the usual systems for street navigation. For agriculture, dirt roads, bridge loads and other agricultural aspects must be marked on the maps. In addition, one-way street rules must be able to be deposited so that no two transport vehicles meet on a dirt road. Agricultural navigation systems must also be able to plan very dynamically on the basis of the harvest data since crop quantity, ground conditions or machine condition can change the distances. The variety of influencing factors make the development of special systems for agriculture difficult, which is why paper cards are often still to be found as a safety system in practice (Steckel, 2015).

Another digital system which promises advantages in logistics is yield recording in the combine harvester or forage harvester. However, both systems show that they record the data too late for direct logistics. There is no time left to plan the logistics accordingly, as the transport vehicles almost have to be at the harvester when they are collected. With the forage harvester, the yield data are sometimes used to divide the costs of transport from different farmers. More interesting for logistics is currently the development of drones or satellites for yield estimation. This data could be available early and precisely enough to even reschedule the logistics in the technology and organization used (Pauli, 2012).

Overloading makes great demands on the drivers of the harvesting vehicle or the transport vehicle, especially at night or after many hours of work. Here digitization also offers opportunities to relieve the driver. From several manufacturers systems are offered in which the track signal of the harvester is charged and transmitted by radio to the transport vehicle. The steering of the transport vehicle is thereby taken over by the harvesting vehicle and the vehicle is always kept at the same distance and speed. This is particularly advantageous for sudden evasive maneuvers of the harvesting vehicle because this information engages directly in the steering of

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. VII, 2018
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

the transport vehicle and thus can prevent accidents caused by the reaction delay of the driver of the transport vehicle.

During the filling process camera systems detect the filling of the transport vehicle and control the forage harvester to optimally load the transport vehicle.

Another important aspect for the digitization of large logistics chains in one area is that all vehicles are clearly identified. For newer harvesters, this can be done via the telematics system.

Many transport vehicles and older tractors do not have this. Here is now the possibility to mark these vehicles with Bluetooth chips.

This chip can be clearly recognized by the other vehicles and thus each vehicle of the chain can be identified. In order to be able to document all data of the transport of a commodity these must be collected digitally.

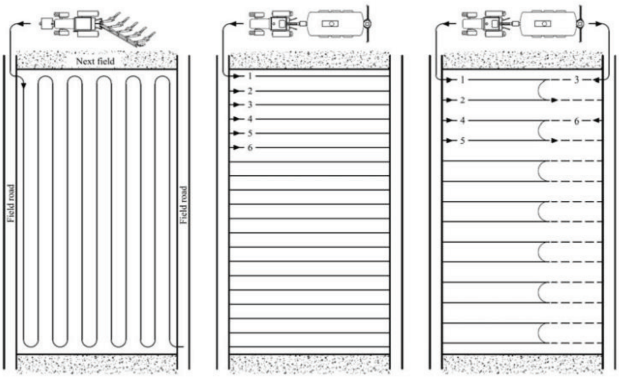
Two systems are currently used for this purpose. In one method all data of the goods are stored separately from the individual machines in a central cloud.

In the other system, the data remain with the goods and are transferred from the harvester to the transport vehicle and then goods and data are transported together to the warehouse (Rusch, 2012).

In the first system, the data is stored very quickly in the cloud, but you have to put data and goods back together properly. In the second method, the data always remain with the goods, but several transmission processes are necessary for this.

Software in agricultural logistics

The spread of digitization in agricultural logistics is well recognized by the use of farm management systems. Farm management systems document, process and analyses all information on location, process flow, technology, employees, costs, etc. of the farm. Farm management systems therefore provide ideal conditions for planning agricultural logistics (Pauli, 2015; Pavlou, 2016). The problem that always shows in practice is that although the appropriate tools for planning are available usually the planning goals cannot be formulated clearly. As an example, the infield logistics can serve here. The pattern of driving on a field e.g. when sowing, fertilizing or harvesting has a significant impact on the associated costs, working hours and effects on the soil structure (Shearer, 2015; Zhou, 2015; Sabelhaus, 2015). It is therefore close to the driving of the fields before a simulation to plan. For this purpose, products are also offered by various manufacturers. However, observations in practice show that these products are not as accepted by the farmers as the advertised savings potential suggests. An analysis of the objectives of the products shows that these are usually optimized for the longest route and the least turning operations. But these are not always the goals of the farmer. Here, the transport capacity of sugar beet harvester or slurry tanker or the location of possible overload points at the edge of the field may determine the route on the field (Mederle, 2015).



a. Most efficient way of working for material neutral operations (e.g. tillage)
b. Material input/output operations without pretended tramlines
c. Tramline distances pretend working width

Figure 2. Different infield-strategies depending on various operations (Mederle, 2017)

To use digital tools to optimize the farm, the real goal of the individual operation must be precisely determined. This is often difficult.

The technical data for farm management systems are usually supplied from telematics systems of the machines. Originally designed purely as a display for IsoBus data, these systems today regulate the collection, processing, display, exchange and documentation of all machine data. Interfaces can also be used to exchange data from different machines. Telemetry systems are thus the basis of many products the previous chapters were presented. But even here, agricultural practice shows that the general use and the economic benefits usually fail due to trifles. In order to transfer the system from the demonstration phase to the general usage, it has to be stable. This is difficult because German agriculture, use different radio network, have different machines with different ages in one logistic chain or different manufacturers and data standards communicate with each other. An example is the radio data transmission. There is a lot of investment to be able to transfer even more data, but especially in rural areas, the network coverage is sometimes bad. Radio network coverage in rural areas is not optimal. Depending on the network provider, it ranges from 89% to 98% in the G4 network (LTS). The average upload rates in rural areas are between 8.41 and 19.53 Mbps, for comparison in the city between 10.65 and 29.02 Mbps on average (Mandau, 2017). Even low power wide area networks such as LoRa or Sigfox do not achieve sufficient coverage in rural areas. Navigation systems for large crop chains do not work if parts of the chain are not currently visible because they cannot transmit their position (Nordemann, 2015; Schattenberg, 2013). Another difficulty is partly the capacity of the data network in the machine. Originally the IsoBus was designed to control the machine. Today, all machine data should also be sent via this data network. To make this possible, the data is compressed. But this also loses information that would be needed in farm management systems. So it would be a new own data network for this data necessary (Weltzien, 2016). Especially on small farms in southern Germany, another problem arises for the digitization of agricultural logistics. Here the machines are used for a long time. Many of these machines do not yet have the required interfaces for data exchange.

Impact of digitization on production chain partners

Logistics also plays a decisive role in trading. Here too the transfer of digital data via the individual trading stages is considered an advantage. When implementing digitization in logistics, the individual trading chains have developed very differently.

In sugar beet production, the individual fields are recorded digitally and all important information, such as grower, rowing order or storage location documented. On the basis of this data, the planning of the shared harvesters is planned. The individual harvester then reports their operating data via GSM. These data can then be used to further fine-plan and to plan the transport. When loading the transport vehicles then all the necessary data of the sugar beets are digitally transmitted and the quality data then reported back to the farmer. All harvest, transport and billing data is recorded in a central database and can be queried online by all parties involved in the process. This system is possible because in southern Germany there is only one central processor of sugar beets with nine sugar factories and one central farming community with 18 000 farmers and 137 000 ha of sugar beet acreage, which are also economically linked. Because everything is in one hand, a functioning digital agricultural logistics system for sugar beet could be established for a long time. Difficulties in the organization can thus be easily clarified. However, the system still has technical problems as discussed in the chapter Software (Gebhard, 2016).

In the digitization of grain logistics, things look quite different. Here, neither the farmers nor the traders have central organizations that can develop a common structure. Here there are only first approaches for a digital data collection in logistics at farmer and trade. These systems are not compatible with each other. When marketing, therefore, the digital data are often given by the farmer on paper to the warehouse and re-entered by this into their digital system.

Both sides have not yet found an organizational structure with which they can digitally share logistics data.

CONCLUSIONS

Overall, the digitization of agricultural logistics in Germany is desired and also necessary. Both the condition in growing farms and the trading requirements point in this direction. The first interesting products can be found on the market. It turns out, however, that there is often still a lack of stability of the systems used. Here the agriculture which works on the area is exposed to special conditions.

An important issue that is not yet sufficiently clarified is the privacy and ownership of the data collected. Many partners have their own data as well as great interest in the data of the other partners. For fear of being cheated or exploited by others, most of them withhold their data. There is currently no structure regulating the data exchange. A shared data usage would bring economic benefits to all partners, but how these benefits have to be distributed to all just needs to be clarified.

REFERENCES

Bernhardt, H., 2002. Schüttguttransport in landwirtschaftlichen Betrieben Deutschlands. Dissertation Justus-Liebig-Universität Giessen, Germany.

Deeken, H., Krampe, F., Steckel, T., 2017. Verbesserung logistischer Prozesse durch Dezentralisierung von Entscheidungen, 37. GIL-Jahrestagung „Digitale Transformation - Wege in eine zukunftsfähige Landwirtschaft“, Dresden, ISBN: 978-3-88579-662-6, p. 41- 44.

Folinas D., Aidonis, D., Manikas, I., Bochtis D., 2015. Logistics Processes Prioritization in the Agrifood Sector, International Journal of Agricultural Management, 4, 72-83.

Gebhardt, H., Kirchberger, T., 2016. Rübenanbau und Zuckererzeugung ab 2017, URL http://bisz.suedzucker.de/Downloads/Kuratoriumstagungen/Kuratoriumstagung_2016/Gebh ard Hans-Joerg_Kirchberg_Thomas.pdf, 15.2.2017.

Götz, S.; Holzer, J., Winkler, J., Bernhardt, H., Engelhardt, D., 2011. Agrarlogistik – Systemvergleich von Transportkonzepten der Getreidelogistik; Landtechnik, 5, 381-386.

Götz, S., Zimmermann, N., Engelhardt, D., Bernhardt, H., 2014. Influencing factors on agricultural transports and their effect on energy consumption and average speed. Agric Eng Int: CIGR Journal, Special issue 2014: Agri-food and biomass supply chains, 59-69.

Götz, S., Zimmermann, N., Engelhardt, D., Bernhardt H., 2015. Simulation of agricultural logistic processes with k-nearest neighbors algorithm. Agric Eng Int: CIGR Journal, Special issue 2015: 18thWorld Congress of CIGR, 241-245.

Heizinger, V., Bernhardt, H., 2011. Algorithmic Efficiency Analysis of Harvest and Transport of Biomass, Journal of Agricultural Machinery Science, Hrsg. Agricultural Machinery Association Turkey, Volume 7 Number 1, ISSN 1306-0007, p 95-99.

Heizinger, V., 2014. Algorithmic Analysis of Process Chains in Agricultural Logistics, Dissertation, TUM München, Germany.

Kluge, A., 2015. CLAAS Fleet View Mobile application for coordinating the transport logistics in the grain harvest, VDI-MEG Land Technik 2015 Hannover November 2015, 355-358, Düsseldorf: VDI-Verlag 2015.

Lamsal, K., Jones, P., Thomas, B., 2016. Harvest logistics in agricultural systems with multiple, independent producers and no on-farm storage, Computers & Industrial Engineering, 91, 129-138.

Mandau, M, Pauler, W., 2017. Bestes Handynetz 2017/18: Netzabdeckung O2, Vodafone, Telekom im Test Deutschlands härtester Netztest, In: Chip.de, 1/18.

Mederle, M., Heizinger, V., Bernhardt, H., 2015. Analyse von Einflussfaktoren auf Befahrungsstrategien im Feld, 35. GIL-Jahrestagung 2013, 113-116, Geisenheim: GIL, 2015.

Mederle, M., Bernhardt, H., 2017. Analysis of Influencing Factors and Decision Criteria on Infield-Logistics of different Farm Types in Germany, In: CIGR E-Journal, Vol 19. Issue 2, pp. 139-148.

Nordemann, F., Tönjes, R. ‚Pulvermüller, E., 2015. Robust Communication for Agricultural Process Management in Rural Areas How dynamic Combination and Configuration of Communication Technologies enables robust Data Transfers in Rural Areas, VDI-MEG LandTechnik 2015 Hannover November 2015, 95-100 Düsseldorf: VDI- Verlag 2015.

Pauli, A., Angermaier, W., Tüller, G., Bernhardt, H., 2012. Evaluierung von Dokumentationsdaten elektronischer Erfassungssysteme in der Erntelogistik von Biomasse, 32. GIL-Jahrestagung: Informationstechnologie für eine nachhaltige Landbewirtschaftung, 29. Februar.-1. März 2012, Freising: GIL, 2012.

Pauli S., 2015. Automatische Dokumentation von Warenströmen bei Transportprozessen von landwirtschaftlichen Gütern, Dissertation, TUM München, Germany.

Pavlou, D., Orfanou, A., Busato, P., Berruto, R., Sørensenn, C., Bochtis, D., 2016. Functional modeling for green biomass supply chains, Computers and Electronics in Agriculture 122, 29–40.

Proter, M., Heppelmann, J., 2014. How smart, connected products are transforming companies. Cambridge / Hamburg: Harvard Business Review, 03.12.2014.

Rusch, C., 2012. Untersuchung der Datensicherheit selbstkonfigurierender Funknetzwerke im Bereich von mobilen Arbeitsmaschinen am Beispiel der Prozessdokumentation, Dissertation, TU Berlin, Germany.

Sabelhaus, D., Schulze Lammers, P., Meyer zu Helligen, L., Röben, F., 2015. Pfadplanung von landwirtschaftlichen Fahrmanövern, Landtechnik (2015) 4, 123-131.

Schattenberg, J., Harms, H., Lang, T., Becker, M., Batzdorfer, S., Bestmann, U., Hecker, P., 2013. Datenaustausch in mobilen Maschinenverbänden zur echtzeitfähigen Positionierung, Landtechnik (2013) 5, 359-364.

Seufert, H., 2006. Landwirtschaft = QM Qualitätsmanagement im Lebens- und Futtermittelsektor, DLG-Verlag, Frankfurt.

Shearer, S., Wolters, D., Root, P., Klopfenstein, A., Schroeder, B., 2015. Modeling of Grain Harvest Logistics for Modern In-Field Equipment Complements, VDI-MEG LandTechnik 2015 Hannover November 2015, 379-386, Düsseldorf: VDI-Verlag 2015.

Sonnen, J., 2007. Simulation von Ernteprozessketten für Siliergüter. Dissertation, Humboldt-Universität zu Berlin, Germany.

Steckel, T., Bernardi, A., Gu, Y., Windmann, S., Maier, A., Niggemann, O., 2015. Anomaly Detection and Performance Evaluation of Mobile Agricultural Machines by Analysis of Big Data, VDI-MEG LandTechnik 2015 Hannover November 2015, 349-354, Düsseldorf: VDI-Verlag 2015.

Tian-Tian Zhang, Qiao-Yu Zhang, 2015. The application of Internet of Things in the logistics of agricultural products. Design, Manufacturing and Mechatronics: pp. 558-567. https://doi.org/10.1142/9789814730518_0067.

Warkentin, H., Steckel, T., Maier, A., Bernardi, A., 2017. Verbesserung mobiler Arbeitsprozesse mit Methoden von Big Data und Data Analytics. 37. GIL-Jahrestagung „Digitale Transformation - Wege in eine zukunftsfähige Landwirtschaft“, Dresden, ISBN: 978-3-88579-662-6, p 161-165.

Weltzien, C., 2016. Digitale Landwirtschaft – oder warum Landwirtschaft 4.0 auch nur kleine Brötchen backt, Landtechnik, Bd. 71, Nr. 2.

Wörz, S., 2017. Entwicklung eines Planungssystems zur Optimierung von Agrarlogistik Prozessen, Dissertation, TUM München, Germany.

Zhou, K., Leck Jensen, A., Bochtis, D., Sørensen, C., 2015. Simulation model for the sequential in-field machinery operations in a potato production system, Computers and Electronics in Agriculture, 116, 173–186.